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Behaviour and food plants of the *Amphipyra* larvae (Lepidoptera, Noctuidae)

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Abstract Larval movement, falling and motionless posture (reaction to the stimulus) of the Japanese *Amphipyra* species were observed. Only the first instar larva of *A. livida* swung the anterior half of body before crawling, and was more responsive to the vibrating stimulus than other species. Some host plants of larvae were recorded for the first time, and larva of *livida* showed a tendency to be adaptive as a feeder of herbal plants.

Key words *Amphipyra* species, larval behaviour, food plants, herbal feeder.

Introduction

Seven species of the genus *Amphipyra* are known in the mainland of Japan. Adults of all the species emerge in early summer and spend several months at aestivation sites such as crevices of dead trees and on panels of old wooden buildings. Eggs laid in autumn hatch in spring and mature larvae spin cocoons about a month after hatching. The larvae of 6 species are polyphagous, except a monophagous *subrigua* Bremer (Owada & Yamamoto, 1983).

Materials and methods

1) Falling response of first instar larva to vibrating stimulus
About ten individuals of the first instar larvae (1 or 2 days old after hatching) of *A. livida, tripartita* and *monolitha* were put on a filter paper (11.0 cm in diameter). The filter paper is turned over and vibrated on the speaker with 60 Hz for a minute (instruments: Audio Amplifier by Shimazu Rika Instrument Co., LTP and 16 cm speaker EAS-16P24SC by Nihon Electric Co.). After a continuous vibration, the number of falling larvae was counted. Experiments were carried out repeatedly from February to March, 1992.

2) Larval food plants
Host plants of the *Amphipyra* larvae were searched at the aestivation sites of adults in Tokai region, central Japan, in 1989-91. The plant leaves with larvae were carried to the laboratory so that the larvae were able to develop completely. Second instar larvae were reared with many kinds of plants to investigate adequate or inadequate ones. About 500 larvae were reared individually in a plastic case (3.3 cm in diameter, 43 ml.) which was maintained at room climatic conditions. The leaves were replaced with fresh ones every day and excrements were swept away. The pupae were weighed just after pupation and sexes were recorded.

Results and discussion

I. Observation of larval movement and falling.

1) Crawling movement of the first instar larva
The first instar larvae are 2-3 mm in body length. Judging from their adult sizes (20.5± 0.75-27.0±1.37 mm in forewing length), they are too small (Funakoshi, 1989). Larva of *A. schrenckii* is reddish brown and a little fat, while those of other species are greenish brown and slender. Four pairs of prolegs A3-6 are present, in which A5 and A6 prolegs are especially distinct in each species. Larvae crawl in loop-shaped movement, but larva of *A. livida* lifts up the anterior half of body and swings it like a pendulum before the crawling movement (Fig. 1). This swing was counted six times ($\bar{x}$: 6.1, n : 10). On contact with a material above the body, the crawling larva catches it by the prothoracic legs. When the larva grows to the second instar, this movement disappears and changes to vermiculation as the larvae of other species.

2) Motionless posture and falling of larva
First instar larvae of *Amphipyra* keep the motionless posture in response to a stimulus, such as breathing and vibration. The posture of each species is shown in Fig. 2. When the stimulus is strong, the larva falls down. At this time, larva of *livida* does not spin but falls directly to the ground, whereas almost all individuals of other species spin to fall and hang in the air above the ground (Table 1). The second to last instar larvae also take the motionless posture upon a stimulus, but their postures differ from that of the first instar larva. Larvae of *livida* curl the body and some of them roll down to the ground, while those of other species lift up the anterior half of the body and keep still for a while.

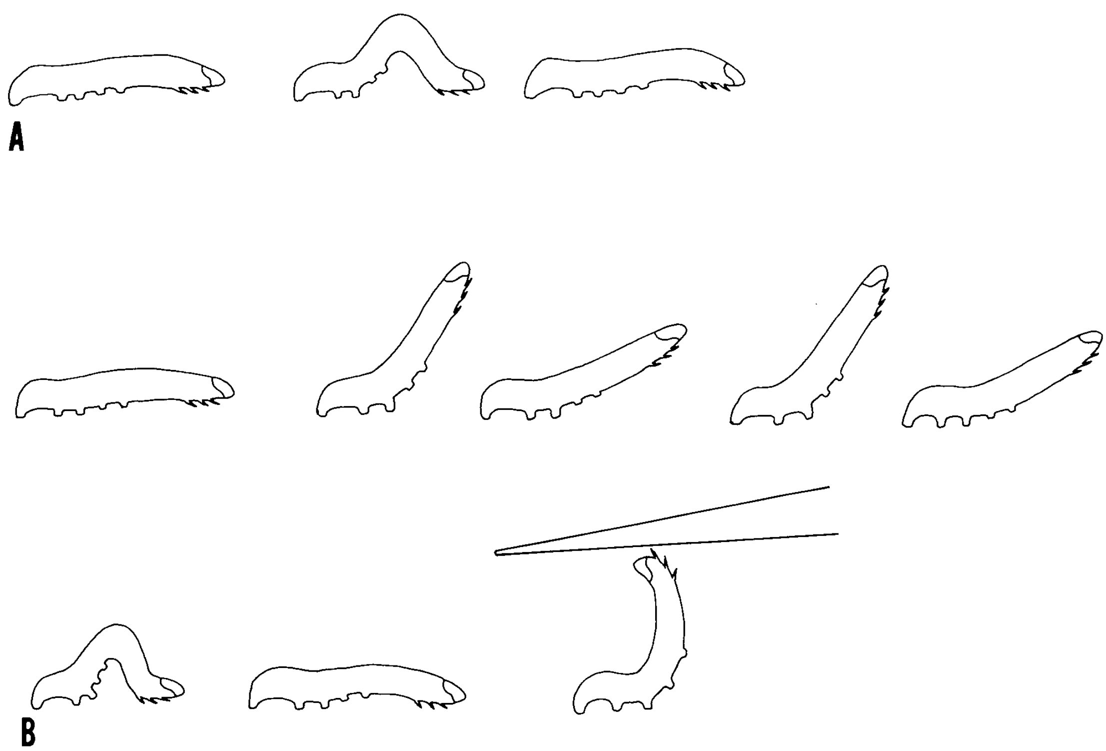

Fig. 1. Movements of the first instar larvae of *Amphipyra*. A. Crawling movement. B. Larva of *A. livida* shakes the half of body and catches the material.

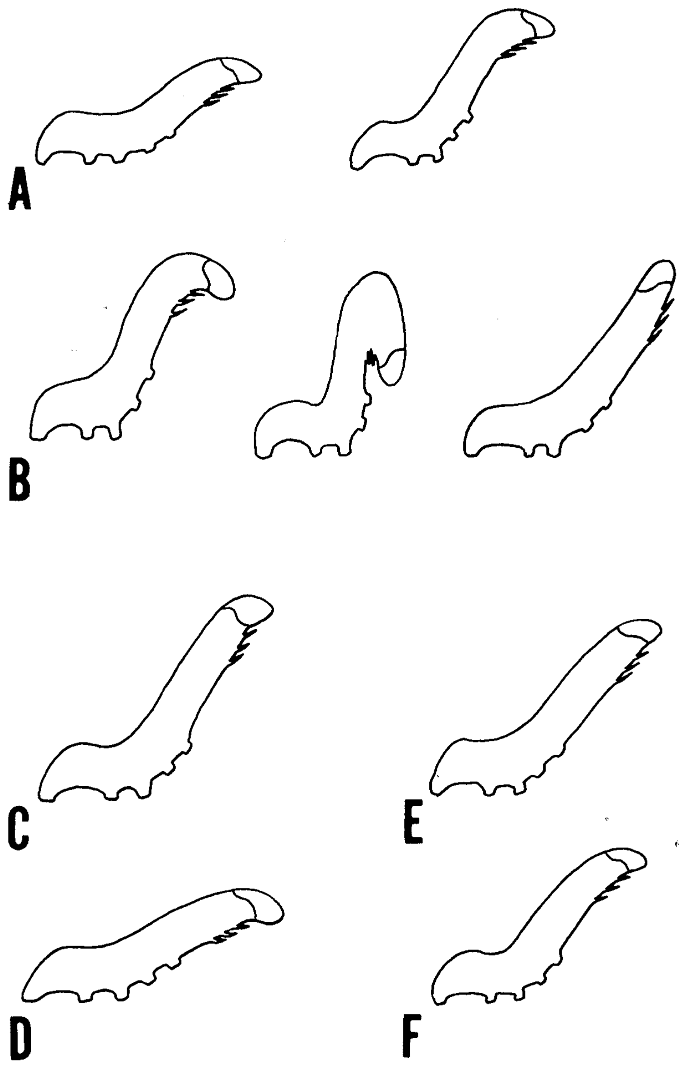

Fig. 2. Motionless postures of the first instar larvae. A. *Amphipyra monolitha* and *pyramidea*. B. *A. livida*. C. *A. tripartita*. D. *A. schrenckii*. E. *A. erebina*. F. *A. subrigua*.

Table 1. The behaviour of first instar larvae of *Amphipyra* species.

	Lifting body	Motionless time (second, n=10)	Spin to fall
A. pyramidea	high	ca. 30	+
A. monolitha	high	ca. 30	+
A. livida	high	ca. 10	−
A. tripartita	high	35–270	+
A. schrenckii	low	1–5	+
A. erebina	high		+
A. subrigua	high	5–15	+

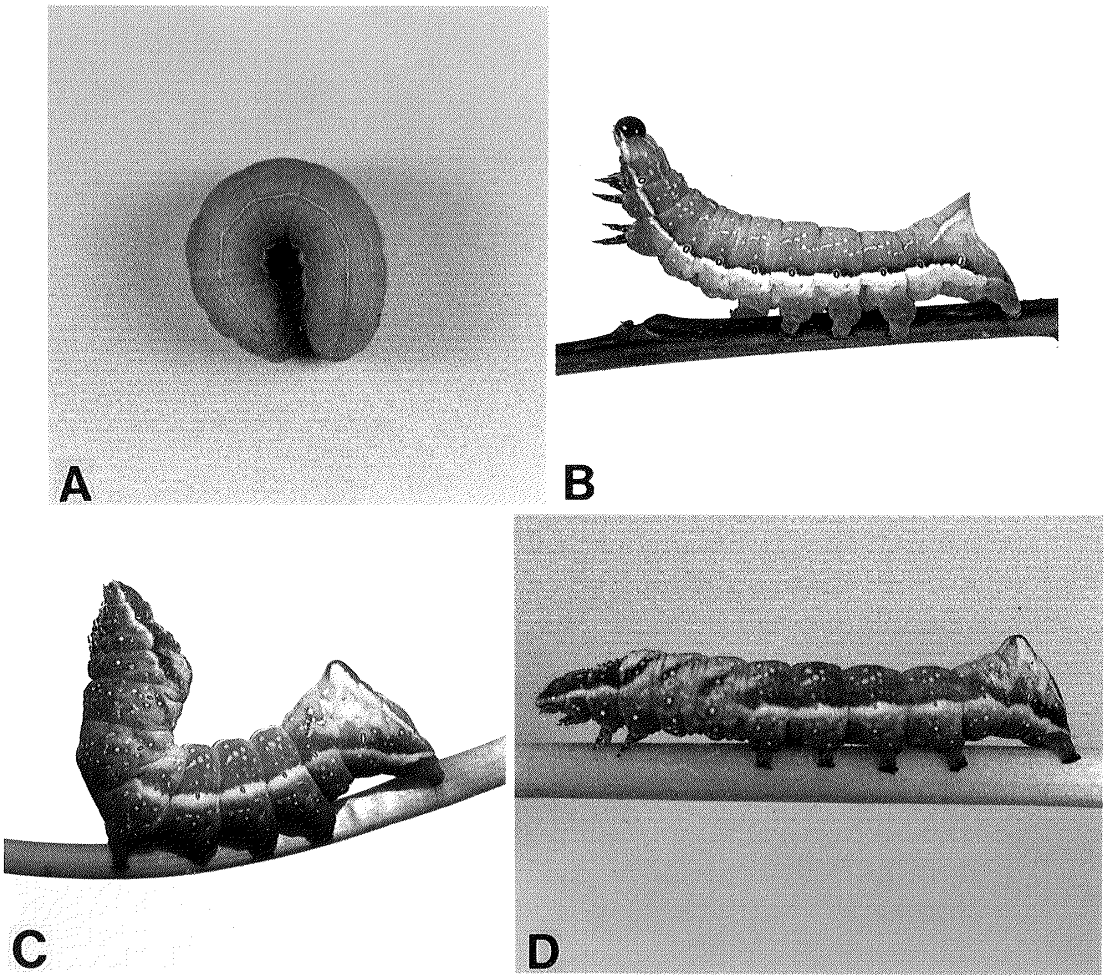

Fig. 3. A-C. Motionless posture of final instar larvae of *Amphipyra*. A. *A. livida*. B. *A. monolitha*. C. *A. tripartita*. D. Resting posture of final instar larvae of *A. tripartita*.

Larvae of *A. tripartita* bend the anterior half of body to the right angle (Fig. 3). Some of them spit a drop of liquid from their mouth.

II. Relationship between vibration and falling of the first instar larva

As shown in Table 2, most of the larvae of *livida* fell off the filter paper when the vibrating

Table 2. Number of the first instar larvae of *Amphipyra* species that fall as a result of vibrating stimulus.

	No. of larvae examined	fallen (%)
A. livida	91	68(74.7)
A. tripartita	129	37(28.7)
A. pyramidea	84	6(7.1)
A. monolitha	82	9(10.9)

Table 3. Food plants of *Amphipyra* larvae.

	Family	Species
A. livida	Fagaceae	*Quercus variabilis* Bl.[10]
	Moraceae	*Cannabis sativa* L.[1,4,6]
	Polygonaceae	*Reynoutria japonica* Houtt.[9]
	Rosaceae	*Rosa hybrida* Hort.[1,4,6]
	Leguminosae	*Dumasia truncata* Sieb. et Zucc.[1,4,6]
	Vitaceae	*Vitis vinifera* L.[5], *Cayratia japonica* Gagnep.[1,4,9]
	Umbelliferae	*Oenanthe javanica* DC.[1,4,6], *Daucus carota* L.
	Compositae	*Taraxacum platycarpum* Dahlst.[1,4,6], *Cirsium japonicum* DC.
	Liliaceae	*Tulipa edulis* Bak.[1,4,6]
A. monolitha	Fagaceae	*Quercus glauca* Thunb., *Q. serrata* Thunb.[9] *Q. acutissima* Carruth[9], *Q. variabilis* Bl.
	Ulmaceae	*Celtis sinensis* Pers.[1,4,6,9]
	Theaceae	*Eurya japonica* Thunb.[4], *Cleyera japonica* Thunb.
	Rosaceae	*Prunus* spp.[1,4,5]
	Aceraceae	*Acer palmatum* Thunb.
	Elaegnaceae	*Elaeagnus umbellata* Thunb.[4]
	Oleaceae	*Ligustrum japonicum* Thunb.
A. pyramidea	Fagaceae	*Quercus serrata* Thunb.[4,9], *Q. acutissima* Carruth[4,9], *Q. variabilis* Bl.[10]
	Rosaceae	*Malus pumila* Mill.[1,5,6], *Malus halliana* Koehne[6] *Prunus* spp.[1,2,4], *P. persica* Batsch[1,5] *P. salicina* Lindl.[5], *Pyrus serotina* Rehd.[1,2]
	Vitaceae	*Vitis vinifera* L.[1]
	Oleaceae	*Syringa reticulata* Hara[6]
A. tripartita	Fagaceae	*Quercus glauca* Thunb.
	Theaceae	*Cleyera japonica* Thunb.
A. schrenckii	Fagaceae	*Fagus crenata* Bl.[8]
A. erebina	Fagaceae	*Quercus glauca* Thunb.
	Ulmaceae	*Zelkova serrata* Makino[1]
	Rosaceae	*Malus pumila* Mill.[1]
		Prunus persica Batsch[1,5], *P. salicina* Lindl.[5], *P. incisa* Thunb.
	Vitaceae	*Vitis vinifera* L.[1]
	Elaegnaceae	*Elaeagnus umbellata* Thunb.[1]
	Oleaceae	*Ligustrum japonicum* Thunb.
A. subrigua	Buxaceae	*Buxus microphylla* Sieb. et Zucc.[7]

[1] Ogata, 1958. [2] Kawada, 1959. [3] Ijima, 1965. [4] Yamamoto, 1965. [5] Oho, 1981. [6] Miyata, 1983. [7] Owada & Yamamoto, 1983. [8] Togashi, 1984. [9] Yamamoto, 1987. [10] Teramoto, 1990.

Table 4. Suitability as the food plants for *Amphipyra* larvae. (− : died without eating. + : died during larval stage. ⧺ : died in prepupal stage. ⧻ : pupated and adult emerged). *Pupal weights of better growing individual (g).

Plants used as food		*A. livida*		*A. monolitha*		*A. tripartita*	
Family	Species	1	2	1	2	1	2
Equisetaceae	*Equisetum arvense* L.	+		+		⧺	
Ginkgoaceae	*Ginkgo biloba* L.	+		−		−	
Taxodiaceae	*Cryptomeria japonica* D. Don	−		−		−	
Salicaceae	*Salix matsudana* Koidz.	⧻	0.56(♀)*	+		⧻	0.97(♀)
Fagaceae	*Castanea crenata* Sieb. et Zucc.	+		⧺		+	
	Quercus glauca Thunb.	⧻	0.20(♂)	⧻	0.73(♀)	⧻	0.66(♂)
Ulmaceae	*Celtis sinensis* Pers.	⧺		+		⧻	0.86(♀)
	Zelkova serrata Makino	⧺		⧻	0.58(♂)		
Moraceae	*Morus bombycis* Koidz.	⧻	0.67(♂)	+		⧻	0.59(♂)
Urticaceae	*Boehmeria niponoivea* Koidz.	⧺		+		+	
Polygonaceae	*Rumex japonicus* Houtt.	⧺		+		+	
Caryophyllaceae	*Stellaria aquatica* Scop.	⧺		−		−	
Lauraceae	*Cinnamomum camphora* Sieb.	⧻	0.31(♀)	⧺		+	
Ranunculaceae	*Ranunculus quelpaertensis* Nakai	⧻	0.57(♂)	+		+	
Lardizabalaceae	*Akebia quinata* Decne.	⧻	0.47(♂)	+			
Actinidiaceae	*Actinidia chinensis* Planch.	⧺		+		⧻	0.84(♀)
Theaceae	*Camellia sasanqua* Thunb.	−		−		−	
	Eurya japonica Thunb.	+		⧻	0.79(♂)	⧻	0.68(♀)
Papaveraceae	*Corydalis incisa* Pers.	⧻	0.73(♀)	+		⧺	
Cruciferae	*Capsella bursa-pastoris* Medic.	⧻	0.55(♂)	⧺		+	
	Brassica campestris L.	⧻	0.69(♀)	+		⧺	
	Raphanus sativus L.	⧻	0.40(♀)	+		⧺	
Rosaceae	*Kerria japonica* DC.	+		+		+	
Leguminosae	*Wisteria floribunda* DC.	⧺		+			
	Astragalus sinicus L.	⧺		+		−	
	Trifolium repens L.	⧻	0.35(♂)	⧺		⧺	
	Kummerovia striata Schindl.	+		+		+	
	Vicia angustifolia L.	⧻	0.31(♂)	+		+	
	Pueraria lobata Ohwi	⧻	0.47(♀)	⧺			
Oxaslidaceae	*Oxalis corniculata* L.	⧻	0.25(♂)	+		+	
Euphorbiaceae	*Mallotus japonicus* Muell. Arg.	+		+		+	
Aceraceae	*Acer palmatum* Thunb.	+		⧻	0.91(♂)	⧻	0.55(♂)
Aquifoliaceae	*Ilex crenata* Thunb.	−		−		+	
Celastraceae	*Euonymus alatus* Sieb.	+		+		+	
Buxaceae	*Buxus microphylla* Sieb. et Zacc.	⧺		+		−	
	Buxus sempervirens L.	⧻	0.39(♀)	+		+	
Elaegnaceae	*Elaeagnus multiflora* Thunb.	⧻	0.57(♀)	⧻	0.92(♀)	+	
Violaceae	*Viola mandshurica* W. Bckr.	⧺		+		+	
Cornaceae	*Aucuba japonica* Thunb.	⧻	0.56(♂)	+		−	
Umbelliferae	*Cryptotaenia japonica* Hassk.	⧻	0.46(♀)	+		+	
Ericaceae	*Rhododendron indicum* Sweet	+		⧻	0.61(♀)	+	
Ebenaceae	*Diospyros kaki* Thunb.	+		⧻	0.65(♀)	⧺	
Oleaceae	*Forsythia suspensa* Vahl	+		+			
	Osmanthus fragrans Lour.	⧻	0.60(♂)	⧻	1.03(♂)	⧻	0.80(♀)
Rubiaceae	*Gardenia jasminoides* Ellis	⧺		⧺		+	
	Galium spurium L.	⧻	0.57(♀)	⧺		+	
Scrophulariaceae	*Veronica persica* Poir.	⧻	0.54(♀)	⧺		⧺	
Labiatae	*Lamium amplexicaule* L.	⧻	0.28(♂)	+		+	
Solanaceae	*Solanum tuberosum* L.	−		−		−	
Caprifoliaceae	*Viburnum awabuki* K. Koch	⧻	0.46(♂)	⧺		⧻	0.81(♂)
Compositae	*Artemisia princeps* Pampan.	⧻	0.47(♀)	+		+	
	Petasites japonicus Maxim.	⧻	0.53(♀)	+		+	
	Lactuca sativa L.	⧻	0.54(♂)	⧺		+	
	Taraxacum longeappendiculatum Nakai	⧻	0.58(♀)	⧻	1.11(♀)	⧻	0.79(♀)
Liliaceae	*Allium fistulosum* L.	⧺		+		⧺	
Gramineae	*Alopecurus aequalis* Sobol.	+		+		+	
	Digitaria adscendens Henr.	+		⧺		+	
Orchidaceae	*Cymbidium* sp.	⧻	0.44(♂)	+		+	

stimulus was applied. On the other hand, many individuals of the other three species were motionless and grasped the surface of the filter paper. It seems likely that falling in the larvae of *livida* is an adaptive behaviour to escape immediately from the source of stimulus.

III. Food plants

Table 3 shows the food plants of *Amphipyra* larvae. The following host plants were found for the first time in this survey : *Daucus carota* L. and *Cirsium japonicum* DC. for larvae of *livida* ; *Quercus glauca* Thunb., *Quercus variabilis* Bl., *Cleyera japonica* Thunb., *Acer palmatum* Thunb. and *Ligustrum japonicum* Thunb. for *monolitha* ; *Quercus glauca* Thunb. and *Cleyera japonica* Thunb. for *tripartita* ; *Quercus glauca* Thunb., *Prunus incisa* Thunb., and *Ligustrum japonicum* Thunb. for *erebina*. Generally speaking, the larvae of *livida* are herbivorous, while those of other species eat the leaves of woody trees including fruit trees (Ogata, 1958 ; Kawada, 1959 ; Yamamoto, 1965 ; Ijima, 1965 ; Oho, 1981 ; Miyata, 1983 ; Teramoto, 1990).

Among the three species of *Amphipyra*, larvae of *livida* were most polyphagous and fed on 48.3% of the 58 species of plants tested (Table 4). Table 5 shows pupal weights of *Amphipyra* 3 species reared on *Taraxacum longeappendiculatum* at about 20℃ temperature. Compared with these weight, pupae of *A. livida* reared on *Corydalis incisa, Brassica campestris, Morus bombycis* and *Osmanthus fragrans* grew better than the average size. On the other hand, pupae reared on *Quercus glauca, Oxalis corniculata* and *Lamium amplexicaule* grew worse in spite of becoming adults. Pupae of *A. monolitha* reared on *Taraxacum longeappendiculatum* grew the best and ones on *Osmanthus fragrans, Acer palmatum*, and *Elaeagnus multiflora* did the second best. Though there is a record of food plants on *Celtis sinensis*, the pupae died during the process of rearing. It is thought this plant may not be the main food species for *A. monolitha*. Pupal weights of *A. tripartita* reared on *Salix matsudana, Celtis sinensis, Actinidia chinensis, Osmanthus fragrans* and *Viburnum awabuki* were heavier than the average weight of Table 5.

Also, it was distinctly obvious that larvae of *livida* grew better when feeding on herbal plants than on woody trees. On the other hand, almost all of the individuals of *monolitha* and *tripartita* fed with the leaves of herbal plants except *Taraxacum longeappendiculatum* did not develop completely.

Table 5. Pupal weights of 3 species of *Amphipyra* (reared on *Taraxacum longeappendiculatum* at about 20℃ temperature).

		No. examined	Weight(g)±S.D.
A. livida	♂	27	0.58±0.054
	♀	24	0.67±0.047
A. monolitha	♂	5	1.10±0.085
	♀	11	1.11±0.018
A. tripartita	♂	7	0.71±0.652
	♀	6	0.79±0.057

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摘　　要

カラスヨトウ属幼虫の行動と食草について (船越進太郎)

ヤガ科カラスヨトウ属 (*Amphipyra*) の幼虫は種によって行動上の違いがみられる．すなわち，カラスヨトウ (*A. livida*) の1齢幼虫はルーパー型の歩行運動の前に上半身をもち上げて上下に振る運動 (振り子運動) をくり返し，また，糸を吐かずに落下するが，他の種では振り子運動はみられず，落下しても糸を吐いて空中で止まった．また，ぜん動型の歩行運動をする2齢幼虫以降でも違いがみられた．刺激を与えるとカラスヨトウは丸まって落下するのに対し，その他の種は上半身を持ち上げて静止した．静止姿勢は一齢幼虫から全ての種でみられたが，それぞれの種に特徴あるポーズであった．これらの行動の違いは食性との関わりが深いと考え，食草探索をすると共に，カラスヨトウ，オオシマカラスヨトウ (*A. monolitha*) シロスジカラスヨトウ (*A. tripartita*) の3種幼虫に多くの植物を与えて食草の適応範囲を調べた．この結果，以下の植物を食草として初めて記録するとともに，カラスヨトウでは草本，オオシマカラスヨトウとシロスジカラスヨトウでは木本への適応が強いと考えられ，刺激に対する幼虫の行動の違いに結び付いていると考察された．

カラスヨトウ：ニンジン (*Daucus carota* L.) (セリ科)，ノアザミ (*Cirsium japonicum* DC.) (キク科)．

オオシマカラスヨトウ：アラカシ (*Quercus glauca* Thunb.) (ブナ科), アベマキ (*Quercus variabilis* Bl.) (ブナ科), サカキ (*Cleyera japonica* Thunb.) (ツバキ科), イロハモミジ (*Acer palmatum* Thunb.) (カエデ科), ネズミモチ (*Ligustrum japonicum* Thunb.) (モクセイ科).

シロスジカラスヨトウ：アラカシ, サカキ.

オオウスヅマカラスヨトウ：アラカシ, マメザクラ (バラ科) (*Prunus incisa* Thunb.), ネズミモチ.

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